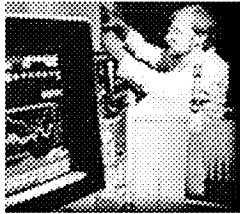
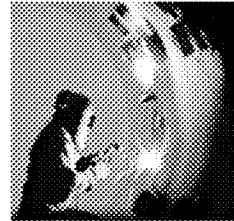


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## **Compressed Gases Safety and Handling**

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## OUTLINE

- Information Sources
  - Emergencies
- Gas Families
  - Industrial / Specialty
  - Nonliquefied / Liquefied
- DOT Hazard Classifications
  - Non-Flammable, Flammable, Oxidizer, Inhalation Hazard, Corrosive
  - Cryogens
- General Safety
  - Handling and Storage
  - Personal Protective Equipment

## **Hazard Communications**

- Label
  - primary means of product identification
- DOT Hazard Class Label or Placard
  - limited information
  - does not address all the hazards
- Container Color
  - should never be used to identify contents
- Material Safety Data Sheets (MSDS) @  
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## **Commercial Families**

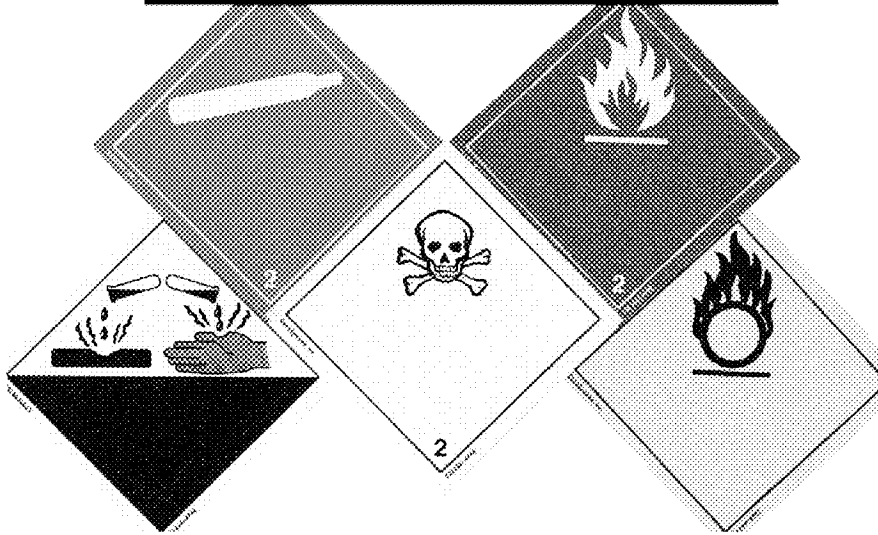
- Industrial Gases
  - atmospheric - nitrogen, oxygen, argon
  - commodity - helium, hydrogen, carbon dioxide
- Specialty Gases
  - industrial gases purified to extreme levels
  - rare gases - Ne, Kr, Xe
  - manufactured gases – SF<sub>6</sub>, Halocarbons
  - mixtures not found in nature - 10% O<sub>2</sub> / N<sub>2</sub>

## **Two Major Groups**

- Determined by the physical state of the product in the container at normal ambient temperatures
- Nonliquefied, permanent, compressed, cryogenic
  - boiling points below -150 °F
  - will not liquefy at ambient temperatures
- Liquefied, liquefied compressed
  - exist in cylinder as a liquid and a gas
  - liquefied by pressure alone

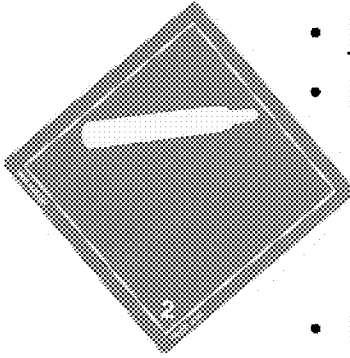
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## **DOT Hazard Classes**



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## Nonflammable Gas

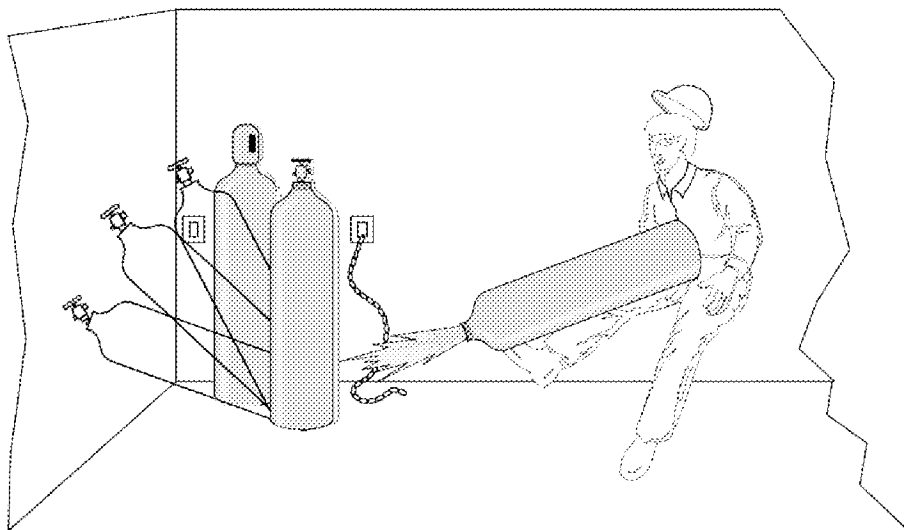


- Most hazardous class of products
- Colorless, Odorless, Tasteless, Non-Irritating
- NO WARNING PROPERTIES
- Hazards
  - pressure 6000 psig
  - asphyxiant 19.5% O<sub>2</sub>
  - *Cryogenic cold*
- Examples
  - argon, helium, nitrogen

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## Pressure



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## **Oxygen Deficiency**

Displacement of oxygen with another gas:

- **19.5%**      legal minimum concentration for humans (OSHA)
- **15-19.5%**    decreased ability to do work, induce early symptoms in persons with coronary, pulmonary or circulation problems
- **12-14%**      increased pulse rate and respiration, impaired perception and judgment

## **Oxygen Deficiency**

- 10-12% further increase in pulse and respiration, giddiness, poor judgment, blue lips
- 8-10% mental failure, nausea, fainting, vomiting, unconsciousness
- 6-8% 8 min 100% Fatal, 6 min 50% fatal, 4-5 min recovery
- 4% coma in 40 sec, convulsions, breathing stops, Death



## Rescue in Oxygen Deficient Atmospheres

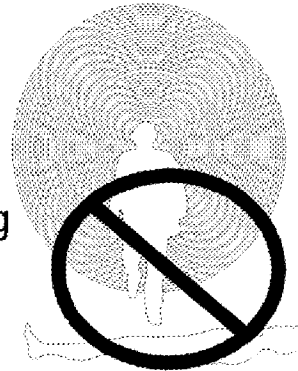
FICTION:

"I can hold my breath long enough  
to run in and save my buddy."

FACT:

You CAN'T !!!

- Over 50% of the workers who die in confined spaces are attempting to rescue other workers.
- Never enter an oxygen-deficient atmosphere without self-contained breathing apparatus.



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### **Nonflammable Gas Hazard Prevention**

- Provide adequate ventilation
- Good cylinder handling procedures
- Monitor the oxygen concentration in confined spaces
- Have Self Contained Breathing Apparatus (SCBA) available
- The most important part of hazard prevention is

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## **Flammable Gas**

- All the same hazards of nonflammable gas
  - pressure
  - asphyxiation
- Plus Flammability
- Examples
  - acetylene, hydrogen, methane



## Gas Flammability

<u>Gas</u>	<u>Flammable Range (air)</u>	<u>Auto-ignition Temperature</u>	<u>Specific Gravity</u>
acetylene	2.5 - 100 %	571 °F	0.906
hydrogen	4 - 74 %	1074 °F	0.070
methane	5 - 14 %	999 °F	0.56
propane	2.1 - 9.5 %	842 °F	1.56
ammonia	16 - 25 %	1562 °F	0.597

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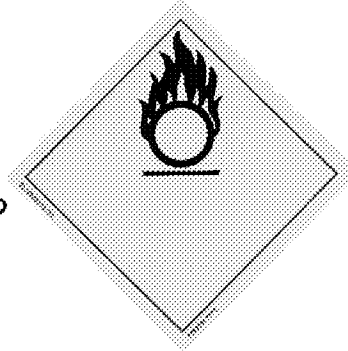
## **Flammable Gas Hazard Prevention**

- Provide adequate ventilation
- Good cylinder handling procedures
- Use of explosion proof equipment
- Elimination of all ignition sources
- The most important part of hazard prevention is

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## Oxidizers

- The “*Good*” gases
  - oxygen - given to us by doctors when we have trouble breathing
  - nitrous oxide - “laughing gas” given to us by dentists as an anesthesia
- Intentionally inhaled
- How can these gases hurt us?



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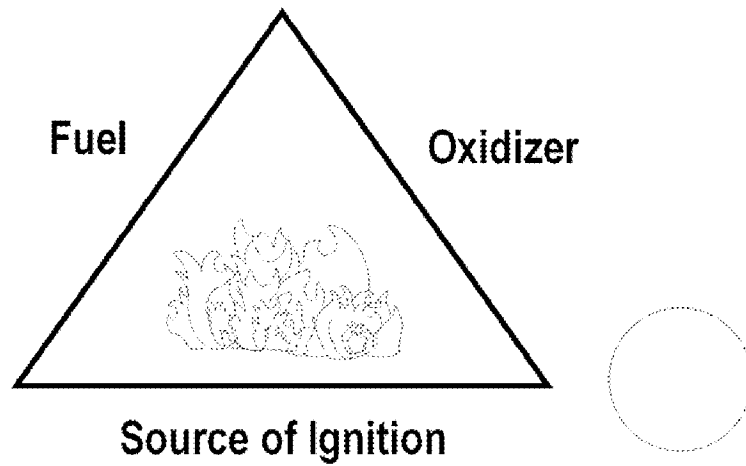
## **Oxidizer Hazards**

- Pressure
- Accelerate Combustion
  - they do not burn
- Increase reactivity
- Oxygen enrichment
- Other examples
  - fluorine, chlorine, chlorine trifluoride

## **Reactivity**

- Increases with concentration and pressure
- Combustible contamination in systems may ignite
  - heat generated from this reaction may spread to the system
  - systems must be cleaned for oxidizer service

## The Fire Triangle



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## **Fuels**

- Common fuels in an atmosphere of air
  - wood
  - coal
  - gas
  - oil
- Fuels in oxidizer atmospheres
  - aluminum
  - stainless steel
  - steel

## **Non-typical Ignition Sources for Oxidizers**

- Velocity
  - particle impingement
- Friction
- Adiabatic heat of compression
- Contamination

## **Oxygen Enrichment**

- Defined as an oxygen concentration of 23.5% or greater
- Fire Chemistry starts to change
  - flammable ranges expand
  - autoignition temperatures start to drop
    - materials that typically would not burn in air will burn in enriched atmospheres
    - materials that readily burn in air will ignite much more easily and burn violently
- Enrichment of clothing is a serious hazard
  - isolate from ignition sources
  - get to fresh air and air out for 30 min
  - change clothes

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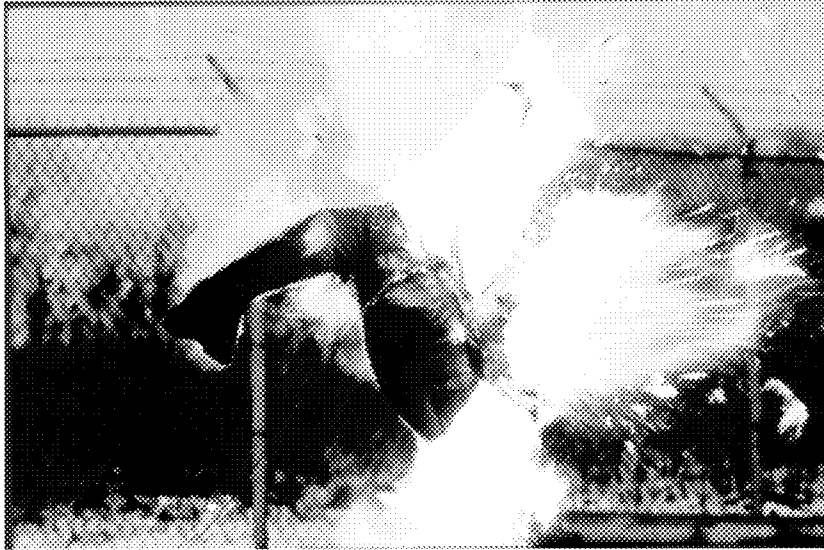
## Oxygen Enrichment Slide 1



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## Oxygen Enrichment Slide 2



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## **Oxidizer Hazard Prevention**

- Provide adequate ventilation
- Good cylinder handling procedures
- Use compatible materials
- Understand and eliminate potential ignition sources
- Insure system cleanliness
- The most important part of hazard prevention is

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## Inhalation Hazard (formerly Poison)

- Toxicity - harm to the body
- Routes Of Entry
  - inhalation
    - most common
  - absorption
    - through skin
  - ingestion
    - not usually applicable
  - injection
    - puncture wounds
- “Safest Class of Gases”
- What’s with all the jargon?



## **Inhalation Hazard Prevention**

- Provide adequate ventilation
- Good cylinder handling procedures
- Monitor for toxics
- Personal Protective Equipment (PPE)
- The most important part of hazard prevention is

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## Corrosives

- Eats human tissue
- Corrodes Equipment
- Not many “gases” have this as a primary hazard
  - hydrogen fluoride, boron trichloride, silicon tetrachloride
- Many gases have as a secondary hazard
  - reactive chlorides, reactive fluorides



## **Corrosivity**

- Usually products are not corrosive unless they find moisture
  - in the atmosphere
  - in your equipment
  - in your body
- Attacks equipment
- Destroys tissue on contact

## **Hazard Prevention for Corrosives**

- Provide adequate ventilation
- Good cylinder handling procedures
- Select compatible materials of construction
  - compatible for dry product and acid
- Eliminate moisture
- Use proper personal protective equipment
- The most important part of hazard prevention is

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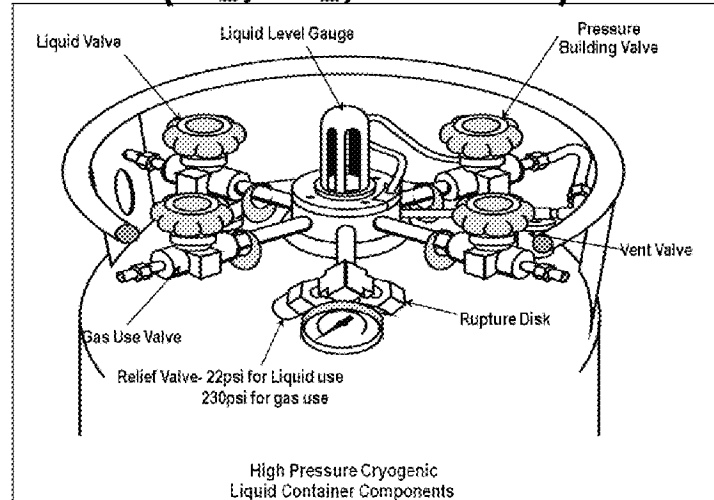
## **Cryogenic Gases**

- Gases with boiling points below - 200 °F
- Examples:

Cryogenic Fluid	Boiling Point
Argon	- 302 °F
Helium	- 452 °F
Hydrogen	- 423 °F
Nitrogen	- 320 °F
Oxygen	- 297 °F

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## **Cryogenic Liquid Container Diagram (N<sub>2</sub>, O<sub>2</sub>, and Ar)**



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## **The Additional Hazards of Cryogenics**

- Cryogenics have all the hazards normally associated with the product at ambient conditions

Plus The Hazards Of

- Extreme Cold
- Large Expansion Ratios
- Fog Clouds

## **Additional Hazards**

- Extreme Cold
  - can cause deep burns to human tissue
  - some materials of construction may become brittle and fail
- Large Expansion Ratios
  - small spills of liquid can very rapidly create
    - oxygen deficiency
    - flammable atmospheres
    - oxygen enrichment
  - Example: 1 volume of  $N_2(l)$  = 697 volumes of  $N_2(g)$
  - rapid over-pressurization of equipment

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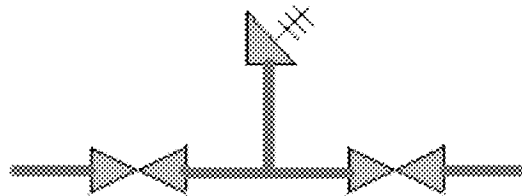
## **Shattered Nitrogen Pipe**



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## **Over-pressurization “Trapped Liquid”**

**Pressure Relief Valve**



**Valves**

## **Hazard Prevention for Cryogenics**

- Provide adequate ventilation
- Use proper personal protective equipment
- Proper system design
  - system compatible with product, temperature and pressure
  - protect areas of system where liquid can accumulate with pressure relief
- The most important part of hazard prevention is  
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### **Personal Protective Equipment**

- General Cylinder Handling
  - safety glasses, leather gloves, safety shoes
- System Operations
  - consult MSDS
- Emergency Operations
  - consult MSDS
- There is no one piece of PPE that can protect against all hazards!
  - product
  - hazard exposure
  - common sense

## **Basic Cylinder Handling and Storage**

Always :

- Wear proper personal protective equipment.
  - leather gloves, safety glasses, safety shoes
- Restrain the cylinder
  - during storage, moving, use
- Make sure the cylinder cap is properly installed when the cylinder is not in use.
- Use a cart when moving cylinders
- Install outlet seals and cylinder caps for return

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## **Basic Cylinder Handling and Storage**

NEVER :

- Drag, roll or slide cylinders
- Lift cylinders by the cap
- Use cylinders as rollers
- Submit to cylinders temperature extremes
- Strike an arc on a cylinder
- Allow cylinders to contact electrical circuits



## **Storage Areas**

- In accordance with CGA Pamphlet P-1
- Use good inventory control, first in first out
- Area should be protected from the elements
- Proper segregation of hazard classes and full & empty
- Easy access
- Secure
- Good housekeeping

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Nothing is more important  
than...  
**SAFETY!**

- RISK REDUCTION!
- EDUCATION OF EMPLOYEES!

**THANK YOU!**

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